TRANSLATOR' S VERIFICATION

I hereby declare and state that I am knowledgeable of each of the Japanese and English languages and that I made and reviewed the attached translation of the Japanese Patent Application No. 2004-029771 filed on February 5, 2004 from the Japanese language into the English language, and that I believe my attached translation to be accurate, true and correct to the best of my knowledge and ability.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of this application or any patent issued thereon.

(Date) June 11, 2009 Noriko Hirose

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[Document Name] Claims

[Claim 1]

A fuel cell disassembly method of disassembling a fuel cell where a pair of separators arranged across an electrode assembly are bonded to each other via an adhesive layer, said fuel cell disassembly method comprising:

a separation facilitating step of causing external heating means to apply heat to the adhesive layer, so as to soften or melt the adhesive layer and thereby facilitate separation of the pair of separators from each other.

[Claim 2]

A fuel cell disassembly method in accordance with claim 1, wherein said separation facilitating step locates the external heating means to be in contact with or close to at least one of the separators.

[Claim 3]

A fuel cell disassembly method in accordance with either one of claims 1 and 2, wherein said separation facilitating step locates the external heating means to cover over a gap between the pair of separators.

[Claim 4]

A fuel cell disassembly method in accordance with any one of claims 1 through 3, wherein said separation facilitating step locates the external heating means along the adhesive layer.

[Claim 5]

A fuel cell disassembly method in accordance with any one of claims 1 through 4, wherein said separation facilitating step causes the external heating means to apply heat to the adhesive layer to be not lower than a softening temperature of the adhesive layer but lower than an upper temperature limit of the electrode assembly.

[Claim 6]

A fuel cell disassembly method in accordance with any one of claims 1 through 5, wherein said separation facilitating step causes the external heating means to apply heat to the adhesive layer, while an external force is applied by external force application means in

a direction of mutually parting the pair of separators.

[Claim 7]

A fuel cell disassembly method in accordance with claim 6, wherein the external force application means in said separation facilitating step comprises a wedge-like member pressed in a direction of insertion into a gap between the pair of separators.

[Claim 8]

A fuel cell disassembly method in accordance with claim 7, wherein said separation facilitating step inserts the external force application means into the gap between the pair of separators, while the external force application means is heated by the external heating means.

[Claim 9]

A fuel cell disassembly method in accordance with claim 6, wherein the external force application means in said separation facilitating step applies the external force to an extension of one of the separators to separate one of the separators from the other of the separators.

[Claim 10]

A fuel cell disassembly method in accordance with any one of claims 1 through 5, wherein said separation facilitating step causes the external heating means to apply heat to the adhesive layer while applying an external force in a direction of mutually parting the pair of separators.

[Claim 11]

A fuel cell disassembly method in accordance with any one of claims 1 through 10, wherein the adhesive layer is arranged around periphery of the electrode assembly and has a sealing function to prevent leakage of a gas fed to the electrode assembly.

[Document Name] Description

[Title of the Invention] Fuel cell disassembly Method

[Field of the Invention]

[0001] The present invention relates to a fuel cell disassembly method of disassembling a fuel cell.

[Background Art]

[0002] A fuel cell of a known structure includes: an electrode assembly that has an electrolyte interposed between a pair of electrodes; sealing layers that are formed along periphery of the electrode assembly; and a pair of separators that are arranged across the electrode assembly and bonded to each other via the sealing layers, where one of the separators facing one of the electrodes has an oxidizing gas conduit, while the other of the separators facing the other of the electrodes has a fuel gas conduit. In the fuel cell of this known structure, a supply of hydrogen is fed as a fuel gas to the fuel gas conduit, whereas a supply of the air is fed as an oxidizing gas to the oxidizing gas conduit. Hydrogen is separated into proton and electron at one of the electrodes (anode) facing the fuel gas conduit. The proton passes through the electrolyte and shifts to the other electrode (cathode), while the electron runs through an external circuit and shifts to the cathode. Oxygen included in the air reacts with the proton and the electron to produce water at the cathode. This electrochemical reaction generates an electromotive force. The sealing layer is an adhesive layer for bonding the two separators to each other and functions to prevent direct contact of oxygen with hydrogen on the peripheries of the respective electrodes.

[0003] Disassembly of the fuel cell is often required for recovery and recycle of the expensive electrode assembly (especially the electrodes containing noble metal catalysts) from the used fuel cell, for separated collection or disposal of the used fuel cell, and for evaluation of the performance of the electrode assembly in the used fuel cell. For example, a fuel cell disclosed in Patent Document

1 indicated below has a linear member placed between sealing layers and a separator. The linear member is pulled out to peel off the sealing layers for disassembly of the fuel cell.

[Patent Document 1] JP 2002-151112 A

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0004] In the prior art fuel cell described in the above cited reference, the worker forcibly pulls the linear member to separate the sealing layer from the separator. The linear member may, however, accidentally be cut in the middle or may not be easily moved. This prior art technique accordingly has difficulty in effectively disassembling the fuel cell.

[0005] The object of the invention is thus to provide a fuel cell disassembly method that ensures effective disassembly of a fuel cell according to the requirements.

[Means to Solve the Problems]

[0006] In order to attain at least part of the above and the other related objects, the present invention is directed to a fuel cell disassembly method of disassembling a fuel cell where a pair of separators arranged across an electrode assembly are bonded to each other via an adhesive layer. The fuel cell disassembly method includes a separation facilitating step of causing external heating means to apply heat to the adhesive layer, so as to soften or melt the adhesive layer and thereby facilitate separation of the pair of separators from each other.

[0007] In the fuel cell disassembly method of the invention, the separation facilitating step causes the external heating means to apply heat to the adhesive layer, so as to soften or melt the adhesive layer and thereby facilitate separation of the pair of separators. The softened or molten adhesive layer weakens the adhesive force between the separators and thereby facilitates separation of the pair of separators. This arrangement ensures effective disassembly of the fuel cell according to the requirements. The technique of the invention is applicable to any types of fuel cells including polymer

electrolyte fuel cells, solid oxide fuel cells, molten carbonate fuel cells, phosphoric acid fuel cells, and alkaline fuel cells.

[0008] In the fuel cell disassembly method of the invention, it is preferable that the separation facilitating step locates the external heating means to be in contact with or close to at least one of the separators. The external heating means is readily arranged in this structure, since the separators have a relatively wide area. In this structure, the heat of the external heating means is applied to the adhesive layer via the separator.

[0009] In the fuel cell disassembly method of the invention, it is also preferable that the separation facilitating step locates the external heating means to cover over a gap between the pair of separators. The adhesive layer is placed in the gap between the pair of separators. This structure thus enables the external heating means to readily apply heat to the adhesive layer.

[0010] In the fuel cell disassembly method of the invention, it is further preferable that the separation facilitating step locates the external heating means along the adhesive layer. This arrangement ensures efficient application of heat from the external heating means to the adhesive layer.

[0011] In the fuel cell disassembly method of the invention, it is also preferable that the separation facilitating step causes the external heating means to apply heat to the adhesive layer to be not lower than a softening temperature of the adhesive layer but lower than an upper temperature limit of the electrode assembly. This arrangement desirably prevents the electrode assembly from being significantly altered or deteriorated by the heat application, which softens or melts the adhesive layer.

[0012] In the fuel cell disassembly method of the invention, it is further preferable that the separation facilitating step causes the external heating means to apply heat to the adhesive layer, while an external force is applied by external force application means to the adhesive layer in a direction of mutually parting the pair of separators. While the adhesive layer is softened or molten to weaken the adhesive force between the pair of separators, the external force

is applied in the direction of mutually parting the pair of separators. This arrangement thus further facilitates separation of the pair of separators. The external force application means may be a wedge-like member pressed in a direction of insertion into a gap between the pair of separators. As the adhesive force of the adhesive layer is weakened, the wedge-like member enters the depth of the gap between the pair of separators to expand the gap. This arrangement thus further facilitates separation of the pair of separators. The external force application means may be inserted into the gap between the pair of separators while being heated by the external heating means. This arrangement ensures additional application of heat to the adhesive layer via the external force application means. The external force application means may apply the external force to an extension of one of the separators to separate one of the separators from the other of the separators. This structure uses the extension of one of the separators to easily separate the pair of separators from each other. The extension may be rims provided on side faces of the separator.

[0013] In the fuel cell disassembly method of the invention, it is preferable that the separation facilitating step causes the external heating means to apply heat to the adhesive layer while applying an external force to the adhesive layer in a direction of mutually parting the pair of separators. While the adhesive layer is softened or molten to weaken the adhesive force between the pair of separators, the external force is applied in the direction of mutually parting the pair of separators. This arrangement thus further facilitates separation of the pair of separators. This arrangement does not require the external force application means, in addition to the external heating means, thus desirably simplifying the whole structure.

[0014] In the fuel cell disassembly method of the invention, it is also preferable that the adhesive layer is arranged around periphery of the electrode assembly and has a sealing function to prevent leakage of a gas fed to the electrode assembly. The adhesive layer having the sealing function desirably simplifies the whole structure,

compared with the conventional structure having separate sealing layer and adhesive layer.

[Best Modes of Carrying Out the Invention]

[0015] Some modes of carrying out the invention are discussed below as preferred embodiments.

[Embodiment]

[0016] Fig. 1 schematically illustrates the structure of a fuel cell 10 in one embodiment of the invention. Fig. 1(a) is a plan view, and Fig. 1(b) is a sectional view taken on a line A-A of Fig. 1(a).

[0017] The fuel cell 10 of this embodiment is a polymer electrolyte fuel cell and includes, as main constituents, a membrane electrode assembly (hereafter referred to as MEA) 2 having an electrolyte membrane 3 interposed between a pair of electrodes 4 and 5, sealing layers 8 located to surround the outer circumference of the MEA 2, and a pair of separators 6 and 7 arranged across the MEA 2 and bonded to the sealing layers 8. The fuel cell 10 is a unit cell having an electromotive force in a range of about 0.6 to 0.8 V. A large number of the fuel cells 10 are tightly laid one upon another to form a direct current power source of several hundred volts as a power supply of, for example, a drive motor of the vehicle.

[0018] The MEA 2 has the electrolyte membrane 3 located between the fuel electrode or anode 4 and the oxygen electrode or cathode 5. In the structure of the MEA 2 of the embodiment, the area of the electrolyte membrane 3 is greater than the areas of the anode 4 and the cathode 5. The electrolyte membrane 3 is mainly made of a solid polymer material having good proton conductivity in wet state, such as a fluororesin membrane (for example, a Nafion membrane manufactured by DuPont). The anode 4 and the cathode 5 respectively have catalyst electrodes 4a and 5a and gas diffusion electrodes 4b and 5b. The catalyst electrodes 4a and 5a are located to be in contact with the electrolyte membrane 3 and are made of electrically conductive carbon black with fine platinum particles carried thereon. The gas diffusion electrodes 4b and 5b are laid upon the catalyst electrodes 4a and 5a and made of carbon cloth of carbon fibers.

Platinum contained in the catalyst electrodes 4a and 5a function to accelerate separation of hydrogen into proton and electron, as well as production of water from oxygen, proton, and electron. Any other catalyst having the same functions may be used in place of platinum. The gas diffusion electrodes 4b and 5b are not restricted to the carbon cloth but may be made of carbon paper or carbon felt of carbon fibers. The carbon material is demanded to have sufficient gas diffusion property and electrical conductivity.

[0019] The separators 6 and 7 are made of a gas-impermeable electrically conductive material, for example, gas-impermeable molded carbon or a metal, such as stainless steel. The separators 6 and 7 respectively have fuel gas supply inlets 6a and 7a for supply of a fuel gas, fuel gas discharge outlets 6b and 7b for discharge of the fuel gas, oxidizing gas supply inlets 6c and 7c for supply of an oxidizing gas, oxidizing gas discharge outlets 6d and 7d for discharge of the oxidizing gas, coolant supply inlets 6e and 7e for supply of a coolant (for example, a cooling fluid), and coolant discharge outlets 6f and 7f for discharge of the coolant. One of the separators 6 has a fuel gas conduit 6g on a face in contact with the anode 4 of the MEA 2 to allow passage of the fuel gas, and a coolant conduit (not shown) on the opposite face to allow passage of the coolant. The fuel gas conduit 6g has multiple channels that are connected to the fuel gas supply inlet 6a and the fuel gas discharge outlet 6b, while not being connected to the other inlets or outlets. The coolant conduit is, on the other hand, connected to the coolant supply inlet 6e and the coolant discharge outlet 6f, while not being connected to the other inlets or outlets. The other of the separators 7 has an oxidizing gas conduit 7g on a face in contact with the cathode 5 of the MEA 2 to allow passage of the oxidizing gas, and a coolant conduit (not shown) on the opposite face to allow passage of the coolant. The oxidizing gas conduit 7g has multiple channels that are connected to the oxidizing gas supply inlet 7c and the oxidizing gas discharge outlet 7d, while not being connected to the other inlets or outlets. The coolant conduit is, on the other hand, connected to the coolant supply inlet 7e and the coolant discharge outlet 7f,

while not being connected to the other inlets or outlets.

[0020] The sealing layers 8 are formed by solidifying an adhesive (for example, an epoxy adhesive) applied over the whole outer circumference of the electrolyte membrane 3 of the MEA 2 without the anode 4 and the cathode 5. The sealing layers 8 correspond to the adhesive layer of the present invention. The sealing layers 8 seal the space for the fuel gas defined by the electrolyte membrane 3 and the separator 6, while sealing the space for the oxidizing gas defined by the electrolyte membrane 3 and the separator 7. The sealing layers 8 have through holes formed at specific positions corresponding to the respective inlets and outlets 6a through 6f and 7a through 7f formed in the separators 6 and 7.

[0021] The following describes power generation of the fuel cell 10. For power generation of the fuel cell 10, a supply of humidified hydrogen is fed as the fuel gas to the fuel gas supply inlets 6a and 7a, while a supply of the air is fed as the oxidizing gas to the oxidizing gas supply inlets 6c and 7c. The flow of hydrogen goes from the fuel gas supply inlet 6a through the fuel gas conduit 6g to the fuel gas discharge outlet 6b to be discharge outside. The flow of the air goes from the oxidizing gas supply inlet 7c through the oxidizing gas conduit 7g to the oxidizing gas discharge outlet 7d to be discharge outside. The flow of hydrogen passes through the fuel gas conduit 6g, is diffused by the gas diffusion electrode 4b of the anode 4 to reach the catalyst electrode 4a, and is separated into proton and electron by the function of the catalyst electrode 4a. The protons are transmitted through the electrolyte membrane 3 in the wet state and are shifted to the cathode 5. The electrons pass through a non-illustrated external pathway to be shifted to the cathode 5. The flow of the air passes through the oxidizing gas conduit 7g, and is diffused by the gas diffusion electrode 5b to reach the catalyst electrode 5a. The proton, the electron, and oxygen in the air react to produce water and generate an electromotive force at the cathode 5. A supply of the coolant is externally fed into the coolant supply inlets 6e and 7e to keep the temperature of the fuel cell 10 in an adequate temperature range for power generation

(for example, 70 to 80°C). The flow of the coolant goes through the non-illustrates coolant conduits formed in the separators 6 and 7, is discharged from the coolant discharge outlets 6f and 7f, is cooled down by a non-illustrated heat exchanger, and is recirculated into the coolant supply inlets 6e and 7e. The electrolyte membrane 3 of the MEA 2 works to conduct the proton, while functioning as an insulation membrane to prevent the air from directly coming into contact with the hydrogen inside the fuel cell 10. The sealing members 8 prevent the air from being mixed with the hydrogen on the periphery of the MEA 2, while preventing the air and the hydrogen from leaking out of the fuel cell 10.

[0022] The procedure of disassembling the fuel cell 10 is described with reference to Figs. 2 through 4. Fig. 2 is a plan view showing arrangement of heaters 21 through 24 set on the fuel cell 10. Fig. 3 is a sectional view taken on the line B-B of Fig. 2. Fig. 4 is a sectional view showing the sealing layers 8 softened by means of the heaters 21 through 24. As shown in Fig. 2, electric heaters 21 through 24 are located along four sides of the upper separator 6 of the fuel cell 10, that is, along the sealing layers 8. These heaters 21 through 24 correspond to the external heating means of the present invention. As shown in Fig. 3, the heaters 21 and 22 are formed in substantially L-shaped cross section and respectively have upper separator contact planes 21a and 22a that are in contact with the separator 6 and gap cover planes 21b and 22b that cover the gaps between the separators 6 and 7. Like the heaters 21 and 22, the heaters 23 and 24 are also formed in substantially L-shaped cross section and have separator contact planes that are in contact with the separator 6 and gap cover planes that cover the gaps between the separators 6 and 7, although not being specifically illustrated. The heaters 21 and 24 are respectively connected to power supply circuits 25 through 28 as shown in Fig. 2. The power supply circuits 25 through 28 are regulated to start or cut off the power supply to the respective heaters 21 through 24, so as to control on and off the heaters 21 through 24. The respective heaters 21 through 24 receive the power supply and start heating. The electrolyte membrane 3 of the MEA 2

is made of a sulfonic acid group-containing fluorinated polymer having an upper temperature limit of about 230°C, whereas the sealing layers 8 are made of an epoxy resin having a softening temperature of about 130°C. The power supply to the heaters 21 through 24 is regulated to heat the sealing layers 8 in a temperature range of 130 to 200°C. The heaters 21 through 24 keep heating the sealing layers 8 to or over the softening temperature at which the sealing layers 8 are softened or molten as shown in Fig. 4. After the sealing layers 8 are softened or molten to weaken the adhesive force between the pair of separators 6 and 7, the heaters 21 through 24 are detached from the fuel cell 10. The worker then completely separates the pair of separators 6 and 7 from each other with some tool or by hand and removes the MEA 2 from the fuel cell 10.

[0023] As described above, in the structure of this embodiment, the heaters 21 through 24 are used to apply heat to the sealing layers 8 and thereby soften or melt the sealing layers 8, in order to facilitate the mutual separation of the pair of separators 6 and 7. The softened or molten sealing layers 8 weaken the adhesive force between the separators 6 and 7 and thereby facilitate mutual separation of the pair of separators 6 and 7. This arrangement ensures effective disassembly of the fuel cell 10. The heaters 21 through 24 are readily arranged to be in contact with the separator 6 having a relatively wide area. The heaters 21 through 24 are also arranged to cover the gaps between the separators 6 and 7. This arrangement ensures effective application of heat to the sealing layers 8 located in the gaps. The heat of the heaters 21 through 24 is applied to the sealing layers 8 via the gaps between the separators 6 and 7, as well as via the separator 6. This arrangement ensures a quick temperature rise of the sealing layers 8. The heaters 21 through 24 are located along the sealing layers 8. This arrangement enables the heat of the heaters 21 through 24 to be efficiently applied to the sealing layers 8. The heat applied to the sealing layers 8 by the heaters 21 through 24 is not lower than the softening temperature of the sealing layers 8 but is lower than the upper temperature limit of the MEA 2. The MEA 2 is thus not

significantly altered or deteriorated by the heat application, which softens or melts the sealing layers 8. The separators 6 and 7 are bonded to each other via the sealing layers 8, which have the sealing function to prevent leakage of the fuel gas and the oxidizing gas fed to the MEA 2. This structure is desirably simpler than the conventional structure having separate sealing members and adhesive members.

[0024] The embodiment discussed above is to be considered in all aspects as illustrative and not restrictive. There may be many modifications, changes, and alterations without departing from the scope or spirit of the main characteristics of the present invention.

[0025] For example, in the above embodiment, the respective heaters 21 through 24 are formed in substantially L-shaped cross section. As shown in Fig. 5, each heater may have a substantially C-shaped cross section. The heater 21 may have an upper separator contact plane 21a that is in contact with the separator 6, a gap cover plane 21b that covers the gap between the separators 6 and 7, and a lower separator contact plane 21c that is in contact with the separator 7. The other heaters 22 through 24 may be formed to have a similar cross section to that of the heater 21. The heat of the heaters 21 through 24 is applied to the sealing layers 8 via the gaps between the separators 6 and 7, as well as via the separator 6 and via the separator 7. This arrangement ensures a quicker temperature rise of the sealing layers 8. As shown in Fig. 6, each heater may have upper and lower split sections. The heater 21 may have an upper separator contact section 21d that is in contact with the separator 6 and a lower separator contact section 21e that is in contact with the separator 7. The other heaters 22 through 24 may be formed to have similar split sections to those of the heater 21. The heat of the heaters 21 through 24 is applied to the sealing layers 8 via the separator 6 and via the separator 7. This arrangement ensures a relatively quick temperature rise of the sealing layers 8. The heater 21 may be formed as a member having only the upper separator contact plane 21a that is in contact with the separator 6, as a member having only the gap cover plane 21b that covers the gap between the separators

6 and 7, or as a member having only the lower separator contact plane 21c that is in contact with the separator 7.

[0026] In the structure of the above embodiment, an external force may be applied in a direction of mutually parting the pair of separators 6 and 7 under application of heat of the respective heaters 21 through 24 to the sealing layers 8 as shown in Figs. 7 through 9. Fig. 7 is a plan view showing arrangement of the heaters 21 through 24 and insertion members 51 through 54 set on the fuel cell 10. Fig. 8 is a sectional view taken on the line C-C of Fig. 7. Fig. 9 is a sectional view showing the softened and molten sealing layers 8. As shown in Figs. 7 and 8, the insertion members 51 through 54 having wedge-like ends are located on the respective sides of the substantially rectangular fuel cell 10 to be inserted between the separators 6 and 7. Springs 55 through 58 as pressing members press the insertion members 51 through 54 in a direction of insertion between the separators 6 and 7. Other springs 31 through 34 as pressing members press the heaters 21 through 24 toward the separator 6. As shown in Fig. 8, the heaters 21 and 22 among the heaters 21 through 24 are pressed by the corresponding springs 31 and 32 to be forcibly in contact with the separator 6 and the insertion members 51 and 52. The heaters 21 and 22 are formed in substantially L-shaped cross section but do not cover the gaps between the separators 6 and 7 unlike the structure of the embodiment. The heaters 21 and 22 are formed to have upper separator contact planes 21a and 22a that are in contact with the separator 6 and insertion member contact planes 21f and 22f that are in contact with the insertion members 51 and 52. The heaters 23 and 24 are formed to have similar cross sections to those of the heaters 21 and 22, although not being specifically illustrated. The respective heaters 21 through 24 receive the power supply and start heating. Heating raises the temperature of the sealing layers 8 to be not lower than the softening temperature of the sealing layers 8 but lower than the upper temperature limit of the MEA 2. The heaters 21 through 24 keep heating the sealing layers 8 to or over the softening temperature at which the sealing layers 8 are softened or molten. As the sealing layers 8 are softened or molten to weaken the adhesive

force between the pair of separators 6 and 7, the wedge-like ends of the respective insertion members 51 through 54 enter the depths of the gaps between the separators 6 and 7. This applies the force of expanding the gaps between the separators 6 and 7 (see the black arrows in Fig. 9), that is, the external force in the direction of mutually parting the separators 6 and 7. The insertion members 51 through 54 thus further facilitate separation of the separators 6 and 7. The insertion members 51 through 54 are located at the positions of the solid lines and the doted lines in Fig. 7, prior to heating. After heating, the insertion members 51 through 54 are inserted to the positions of the one-dot chain lines in Fig. 7. The insertion members 51 through 54 are inserted into the gaps between the separators 6 and 7, while being heated by the heaters 21 through 24. The sealing layers 8 thus additionally receive heat via the insertion members 51 through 54. This ensures a quicker temperature rise of the sealing layers 8. The heaters 21 through 24 may be omitted from the structure of Figs. 7 through 9, and the insertion members 51 through 54 may be designed to have heating functions. This desirably simplifies the whole structure.

[0027] Another structure shown in Figs. 10 and 11 may be adopted to apply an external force in a direction of mutually parting the pair of separators 6 and 7. Fig. 10 is a perspective view showing application of an external force via wires 66b in the direction of mutually parting the pair of separators 6 and 7. Fig. 11 is a sectional view taken on the line D-D of Fig. 10. A fuel cell 60 has a similar structure to that of the fuel cell 10 described above, except that rims 66 and 67 are formed along respective two sides of the separators 6 and 7. The like elements are expressed by the like numerals and are not specifically described here. In this fuel cell 60, the rims 66 are formed on two opposed side faces of the separator 6 and respectively have two through holes 66a, 66a. Similarly the rims 67 are formed on two opposed side faces of the separator 7 and respectively have two through holes 67a, 67a. A method of disassembling this fuel cell 60 first places the fuel cell 60 on a table 62 in a heating furnace 61, passes the wires 66b downward through

one of the through holes 66a and then upward through the other of the through holes 66a, and passes wires 67b through the through holes 67a, and fixes both the ends of the wires 67b to the table 62. The method then uses a hoist gear 63 to pull up both the ends of the wires 66b and thereby apply an external force of parting the separator 6 from the separator 7 fastened to the table 62. The hoist gear 63 corresponds to the external force application means of the invention. The internal temperature of the heating furnace 61 is regulated to be not lower than the softening temperature of the sealing layers 8. For example, the heating furnace 61 is kept at 500°C for 1 hour to soften or melt the sealing layers 8. This arrangement further facilitates separation of the separators 6 and 7. The rims 66 and the through holes 66a may be arranged at any desirable positions in any desirable numbers, as long as the rims 66 and the through holes 66a function to lift up the separator 6 and do not interfere with smooth supply and discharge of the reactive gases (the oxidizing gas and the fuel gas) and the coolant. The rims 67 and the through holes 67a may be arranged at any desirable positions in any desirable numbers, as long as the rims 67 and the through holes 67a function to fix the separator 7 and do not interfere with smooth supply and discharge of the reactive gases and the coolant.

[0028] Voltage measurement terminals extended from the periphery of the respective separators or stack pressing member attachment elements extended from the periphery of the respective separators, if any, may be used, instead of the rims 66 and the through holes 66a, to apply the external force in the direction of mutually parting the pair of separators 6 and 7. The stack pressing member is used to press multiple fuel cells of a fuel cell stack and thereby make adjoining separators stick together. Typical examples of the stack pressing member include bolts and tension plates. The use of the existing structure or the combined use of the existing structure to receive an external force applied by the external force application means desirably prevents the size increase and the weight increase of the separators.

[0029] The above embodiment uses the electric heaters 21 through 24.

Gas heaters or hot blast heaters may be used instead of the electric heaters. The heaters may also be replaced by gas burners or heating furnaces. In any of these modified structures, the temperature of the sealing layers 8 is measured directly or indirectly and is regulated to be not lower than the softening temperature of the sealing layers 8 but lower than the upper temperature limit of the MEA 2.

[0030] The above first embodiment regards the polymer electrolyte fuel cell. The principle of the invention is also applicable to other types of fuel cells including solid oxide fuel cells, molten carbonate fuel cells, phosphoric acid fuel cells, and alkaline fuel cells.

[Brief Description of the Drawings]

[0031]

Fig. 1 schematically illustrates the structure of a fuel cell 10 in a first embodiment of the invention, where Fig. 1(a) is a plan view, and Fig. 1(b) is a sectional view taken on a line A-A of Fig. 1(a).;

Fig. 2 is a plan view showing arrangement of heaters;

Fig. 3 is a sectional view taken on the line B-B of Fig. 2;

Fig. 4 is a sectional view showing the softened and molten sealing layers 8;

Fig. 5 is a sectional view showing arrangement of heaters of one modified form;

Fig. 6 is a sectional view showing arrangement of heaters of another modified form;

Fig. 7 is a plan view showing arrangement of the heaters and insertion members;

Fig. 8 is a sectional view taken on the line C-C of Fig. 7;

Fig. 9 is a sectional view showing the softened and molten sealing layers;

Fig. 10 is a perspective view showing application of an external force via wires in the direction of mutually parting a pair of separators; and

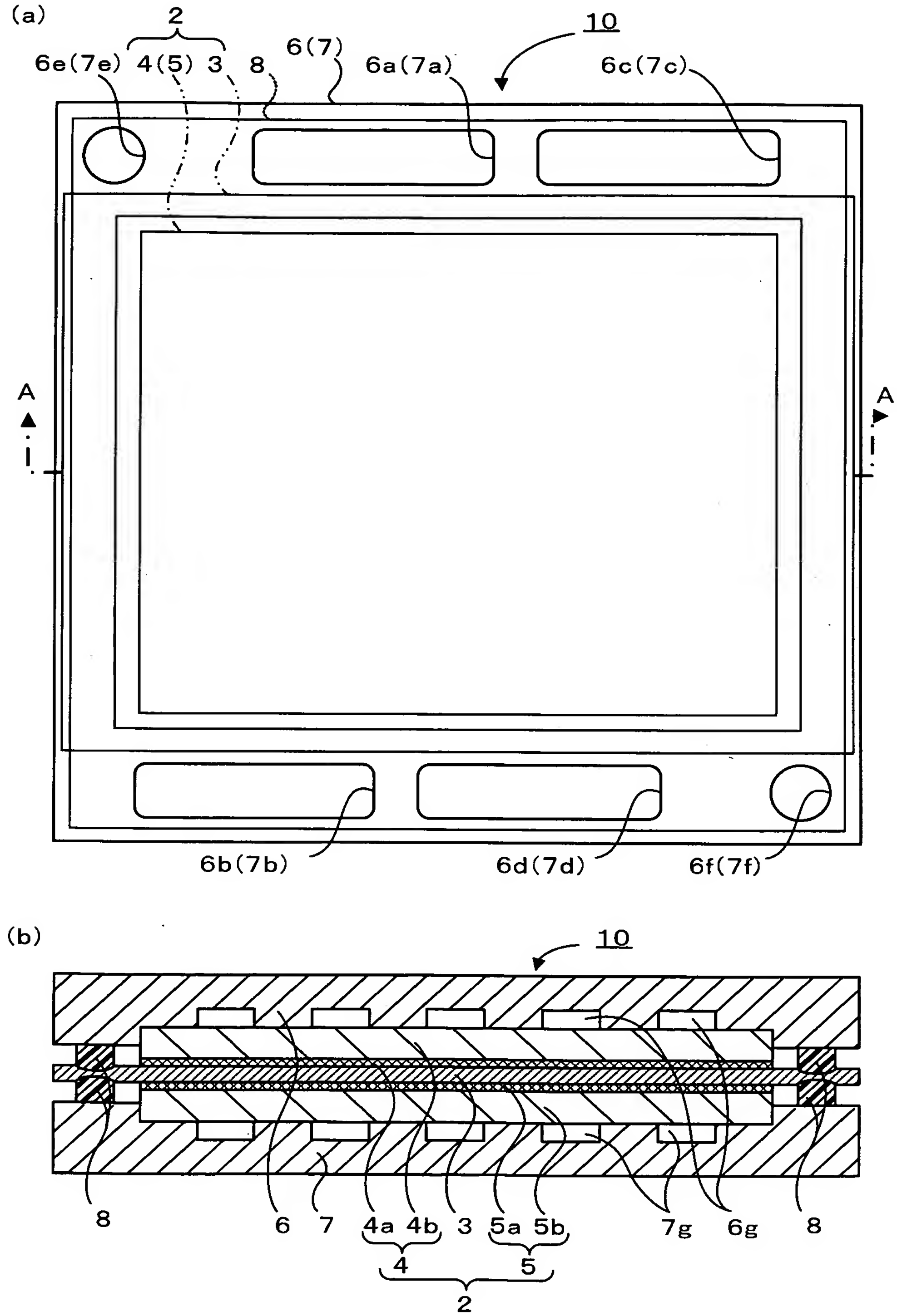
Fig. 11 is a sectional view taken on the line D-D of Fig. 10.

[Explanation of Reference Numbers]

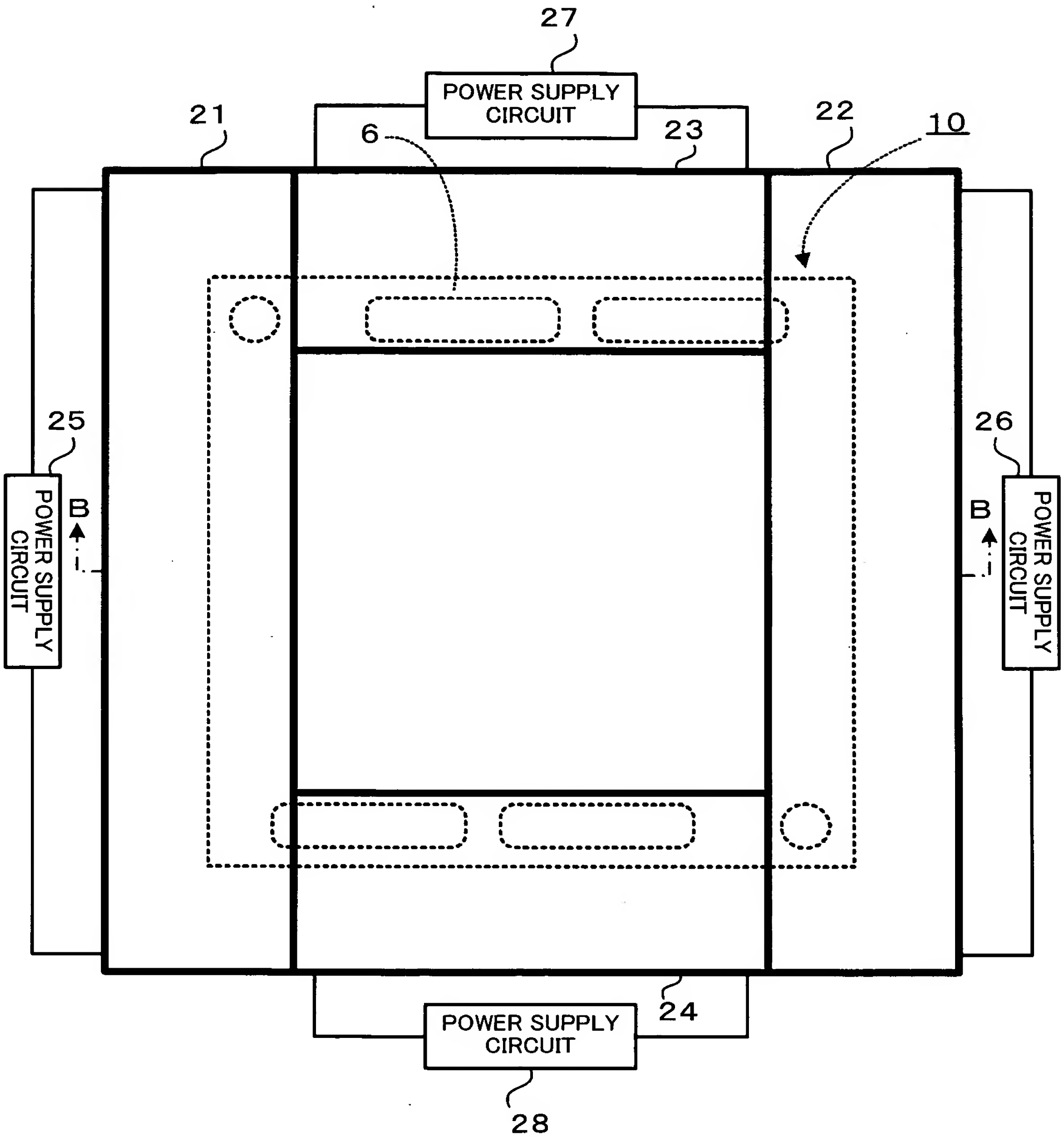
[0032]Membrane electrode assembly (MEA) 2, electrolyte membrane 3, anode (electrode) 4, catalyst electrode 4a, gas diffusion electrode 4b, cathode (electrode) 5, catalyst electrode 5a, gas diffusion electrode 5b, separator 6, fuel gas supply inlet 6a, fuel gas discharge outlet 6b, oxidizing gas supply inlet 6c, oxidizing gas discharge outlet 6d, coolant supply inlet 6e, coolant discharge outlet 6f, fuel gas conduit 6g, separator 7, fuel gas supply inlet 7a, fuel gas discharge outlet 7b, oxidizing gas supply inlet 7c, oxidizing gas discharge outlet 7d, coolant supply inlet 7e, coolant discharge outlet 7f, oxidizing gas conduit 7g, sealing layers 8, fuel cell 10, heaters 21 through 24, separator contact planes 21a, 21c, 21d, 21e, and 22a, gap cover planes 21b and 22b, insertion member contact planes 21f and 22f, heaters 22 and 23, power supply circuits 25 through 28, springs 31 through 34, insertion members 51 through 54, Springs 55 through 58, fuel cell 60, heating furnace 61, table 62, hoist gear 63, rim 66, through hole 66a, wire 66b, rim 67, through holes 67a, and wire 67b.

[Document Name] Drawings

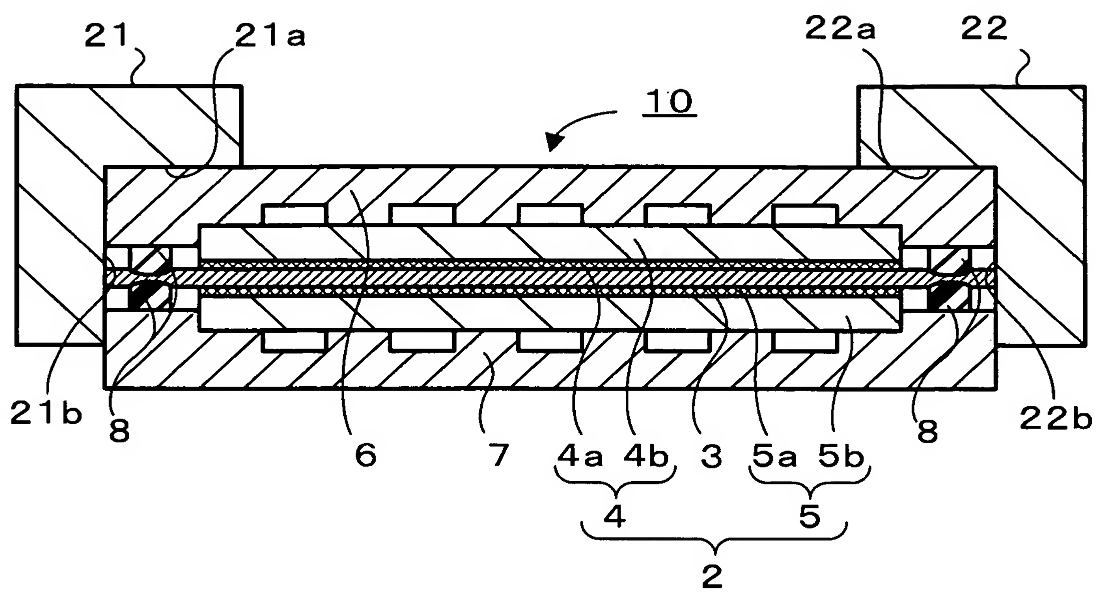
[Fig. 1]



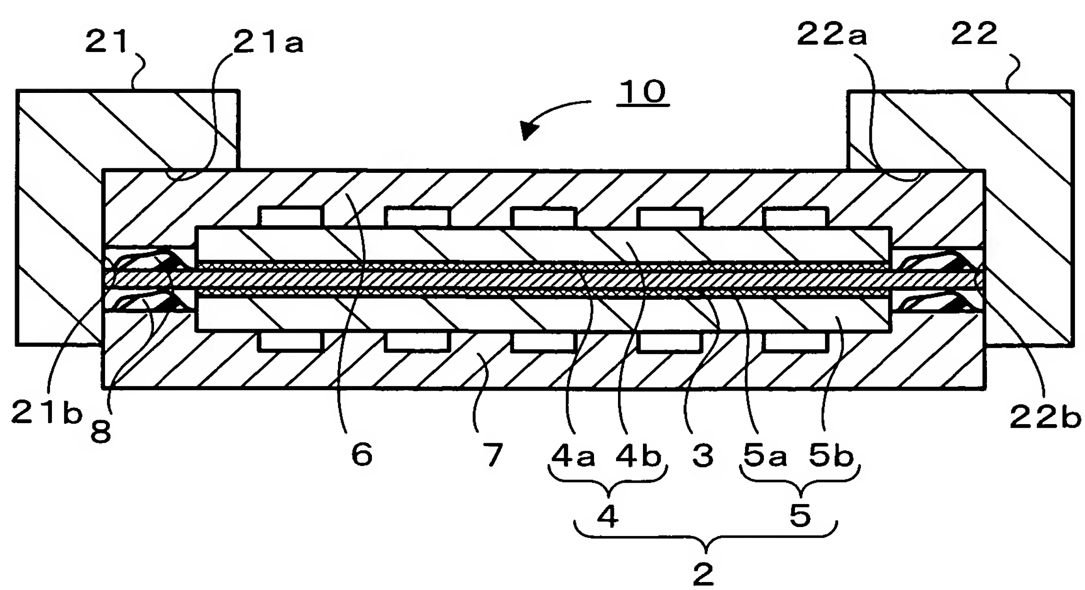
[Fig. 2]


27
POWER SUPPLY CIRCUIT
21
6
23
22
10
25
POWER SUPPLY CIRCUIT
B
26
POWER SUPPLY CIRCUIT
B
24
POWER SUPPLY CIRCUIT
28

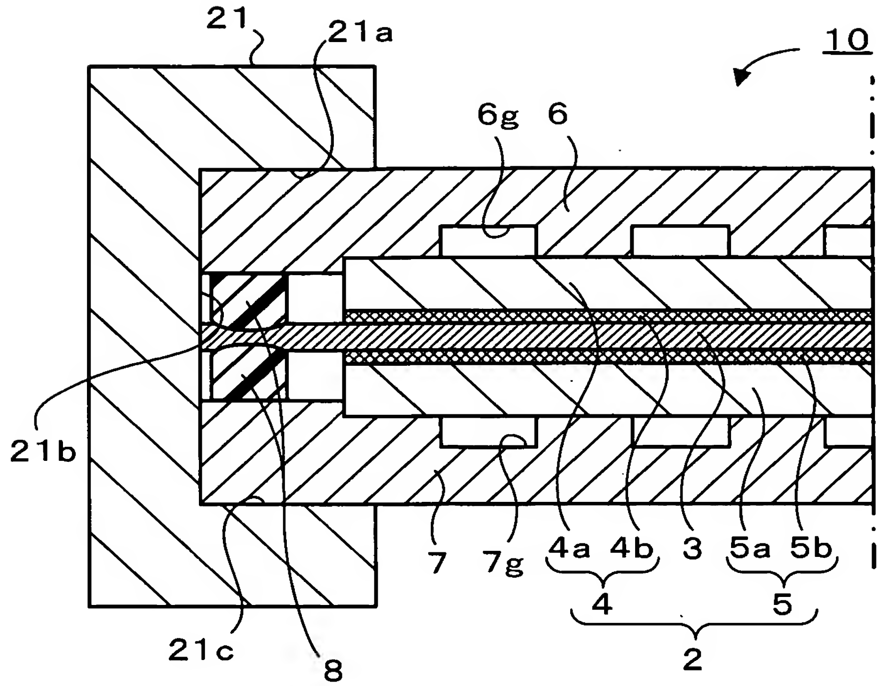
[Fig. 3]


21
21a
22a
22
10
21b
8
6
7
4a
4b
3
5a
5b
8
22b
4
5
2

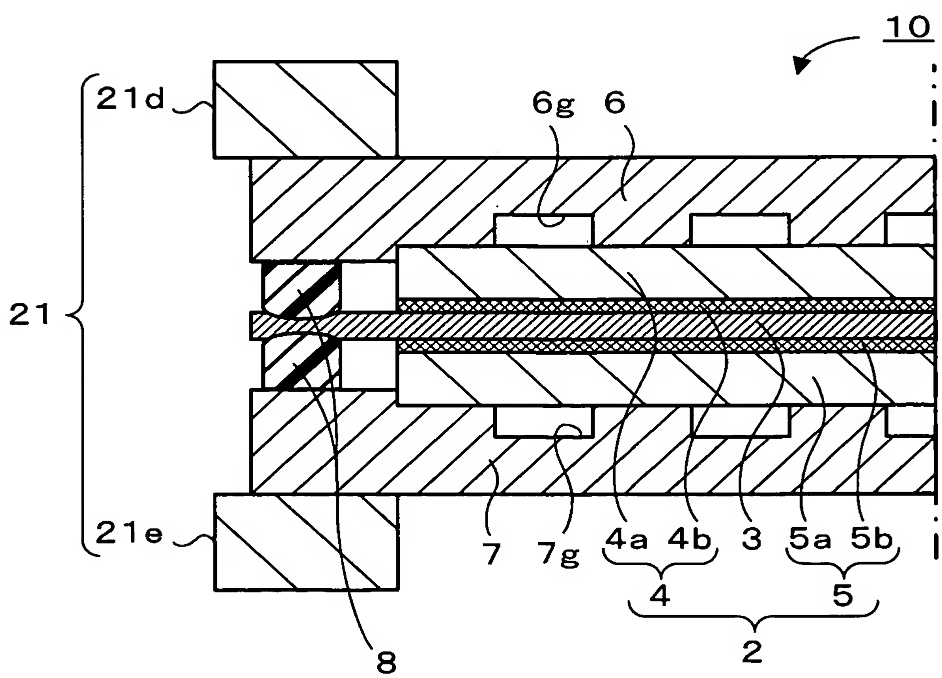
[Fig. 4]


21
21a
22a
22
10
21b
8
6
7
4a
4b
3
5a
5b
22b
4
5
2

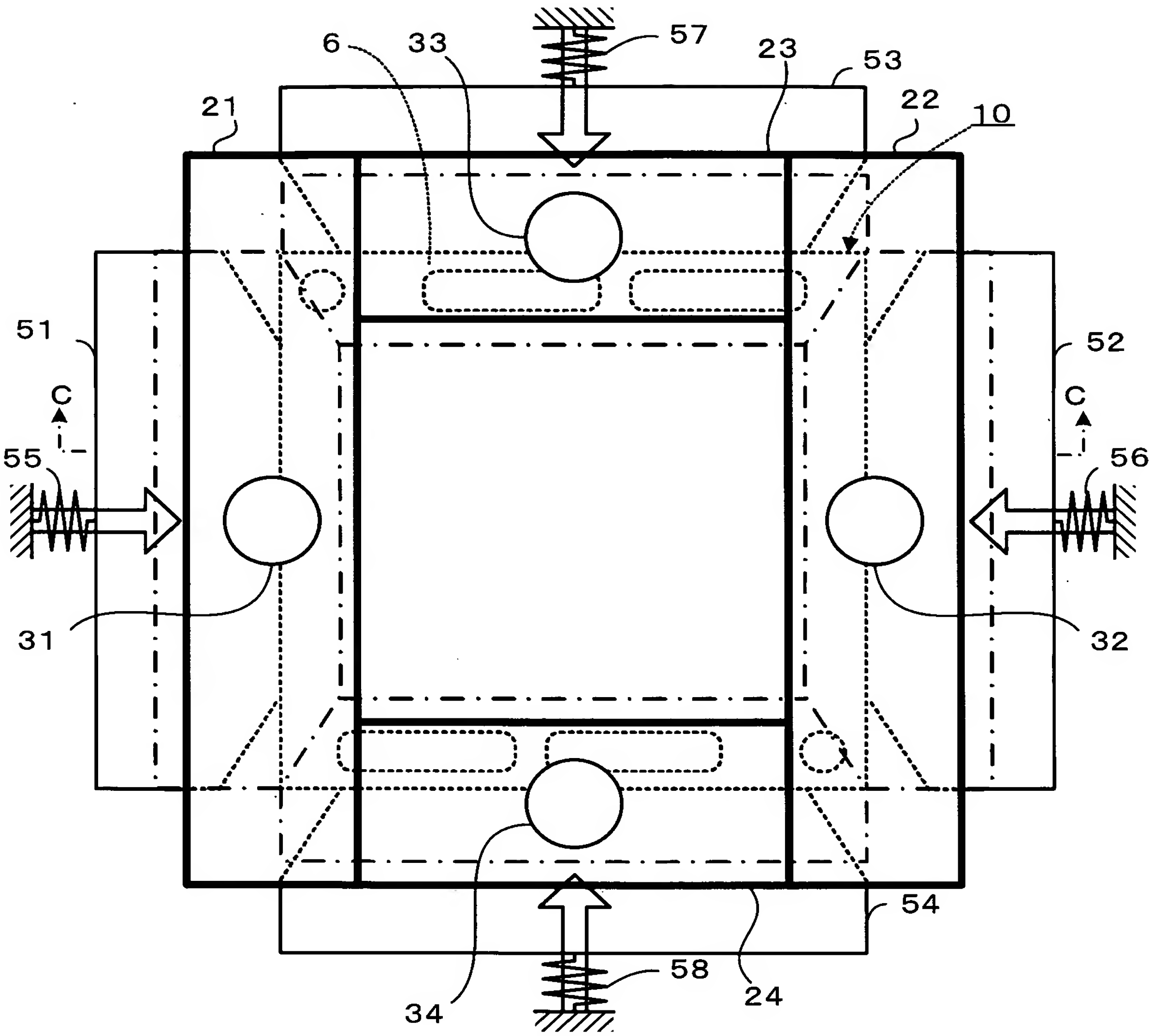
[Fig. 5]


21
21a
10
6g
6
21b
7
7g
4a
4b
3
5a
5b
4
5
2
21c
8

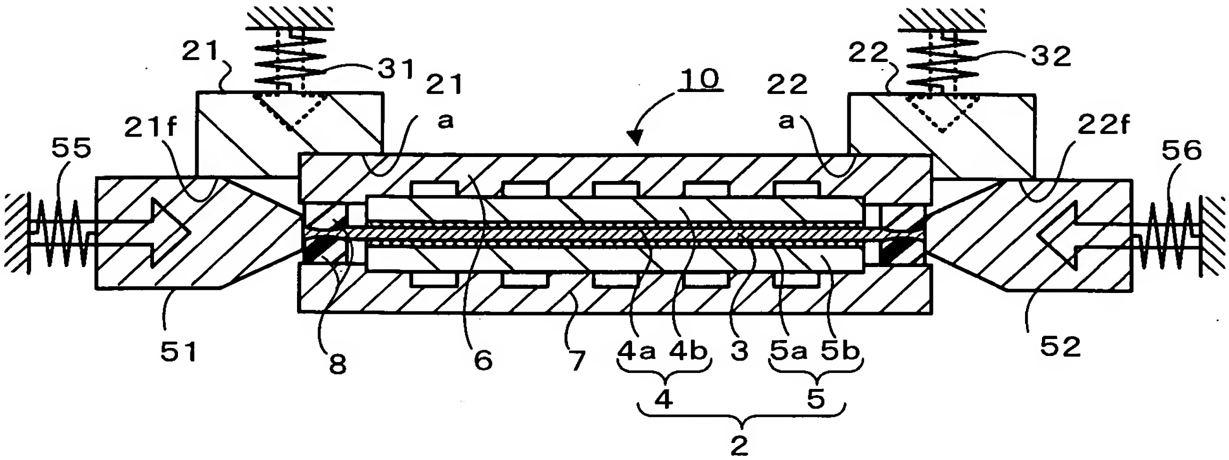
[Fig. 6]


10
21d
6g
6
21
21e
7
7g
4a
4b
3
5a
5b
4
5
2
8

[Fig. 7]

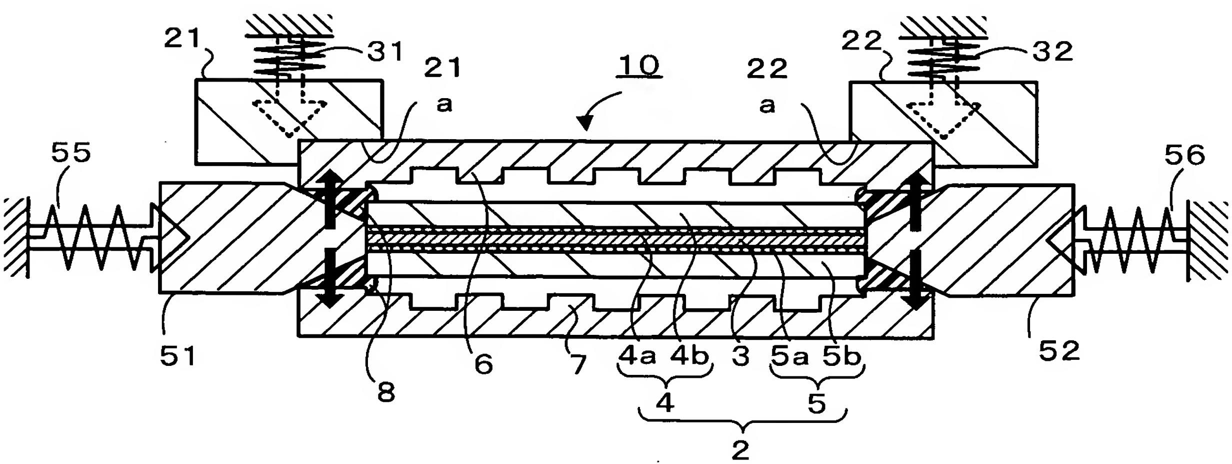


[Fig. 8]



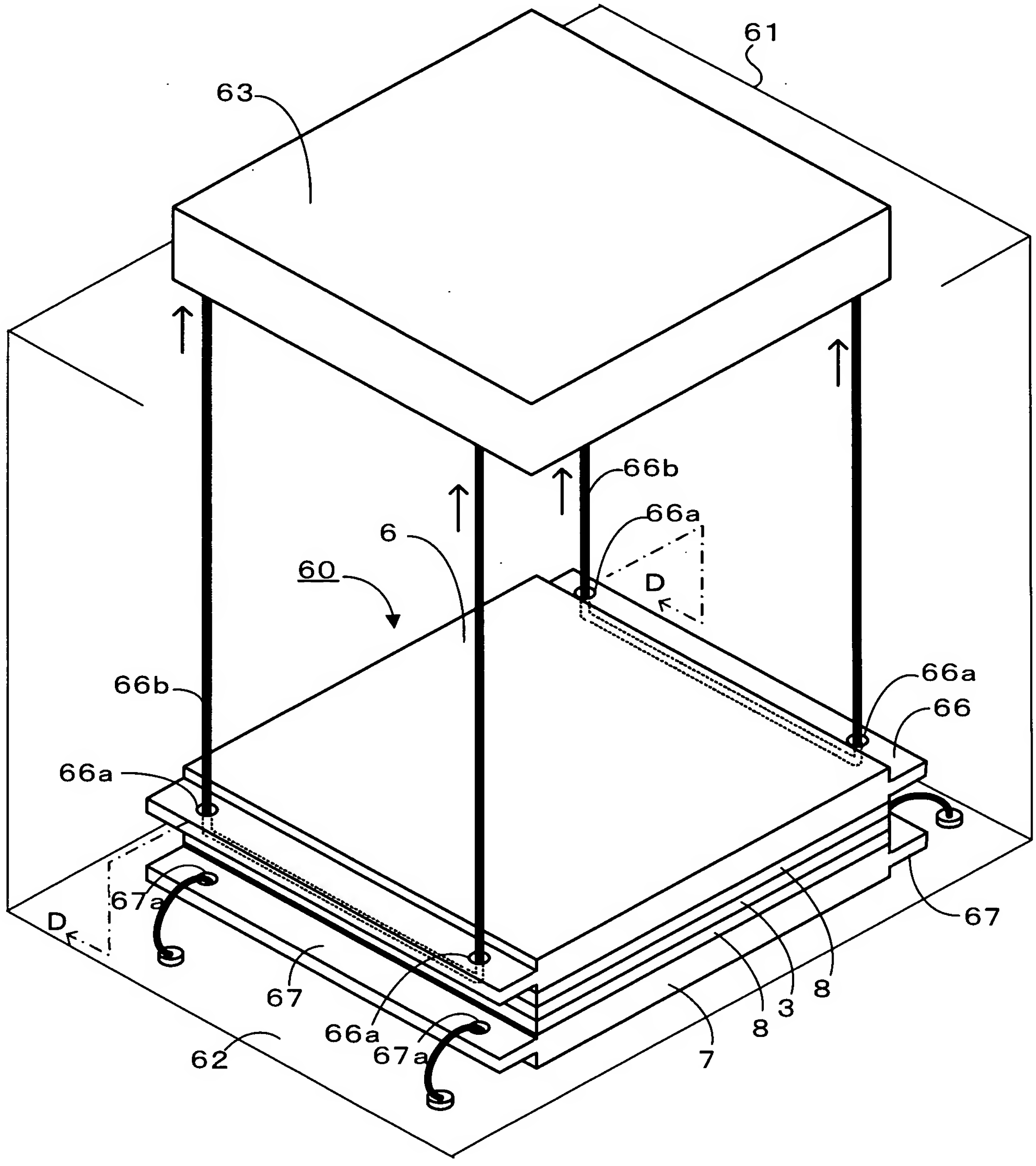
21
31
21
a
10
22
a
22
32
21f
22f
55
56
51
8
6
7
4a
4b
3
5a
5b
52
4
5
2

[Fig. 9]

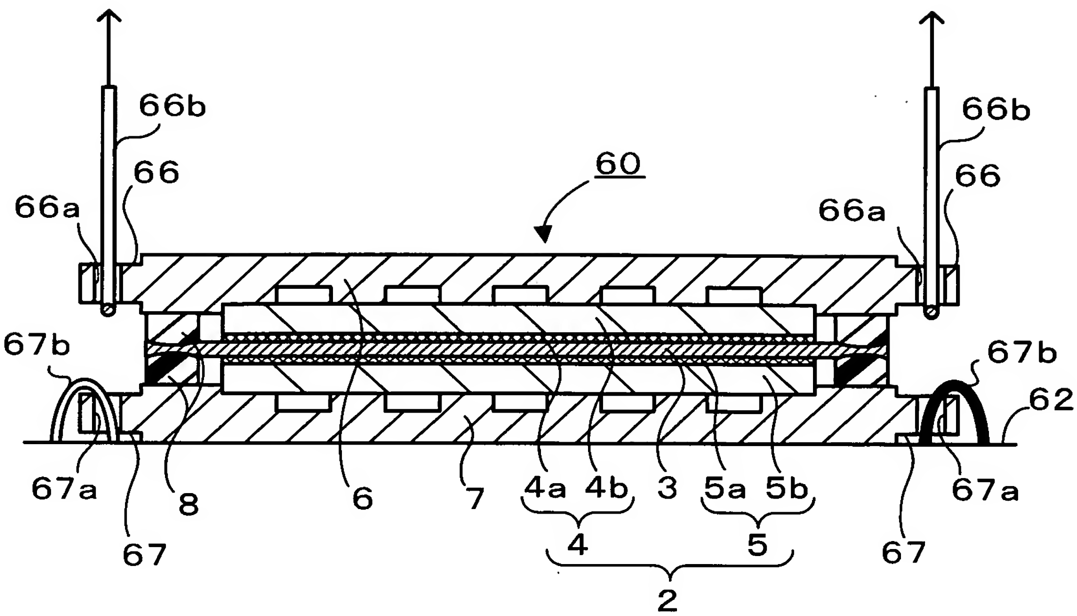


21
31
21
a
10
22
a
22
32
55
56
51
8
6
7
4a
4b
3
5a
5b
52
4
5
2

[Fig. 10]



[Fig. 11]



66b
66b
60
66
66
66a
66a
67b
67b
62
67a
8
6
7
4a
4b
3
5a
5b
67a
4
5
67
67
2

[Document Name] Abstract
[Abstract]
[Problems]
[Means to Solve the Problems]
Respective heaters 21 and 22 receive power supply and start heating. The heaters 21 and 22 keep heating sealing layers 8 to or over a softening temperature at which the sealing layers 8 are softened or molten. After the sealing layers 8 are softened or molten to weaken the adhesive force between a pair of separators 6 and 7, the heaters 21 and 22 are detached from a fuel cell 10. The worker then completely separates the pair of separators 6 and 7 from each other with some tool or by hand and removes an MEA 2 from the fuel cell 10.
[Drawing to accompany with Abstract] Fig. 4